scrambled by the code recording apparatus shown in FIG. 12, and then outputs these random numbers to the logical operation circuit 83.

The logical operation circuit 83 performs a logical operation on the main data supplied from the data divider 81 and the random numbers supplied from the pseudo-random number generator 84, thereby de-scrambling the main data and outputting the de-scrambled main data as reproduced data to the outside through an output I/F 85.

In this way, the data which has been scrambled during recording is de-scrambled during reproduction, so as to be restored into original data.

As is apparent from the foregoing description, in the code conversion method and apparatus of the present invention, if the variation of a calculated value representing a difference between the number of "0" bits and the number of "1" bits in the output main data word (i.e., the variation of a DSV) has exceeded a threshold value, another scramble data is newly selected and the input main data word is scrambled again. The scramble data is repeatedly changed and the scrambling is repeatedly performed until the DSV becomes equal to or smaller than the threshold value. As a result, the increase of the DSV can be prevented and the low frequency components of the output main data word can be reduced.

Thus, when such an output main data word is recorded onto a recording medium and a signal is reproduced from the recording medium, it is possible to reduce the low frequency components of the reproduced signal and to prevent a reproduction error satisfactorily.

In addition, since the DSV can be included within a tolerance range with respect to any input main data word having any pattern, the reproduction error can be satisfactorily prevented.

Furthermore, in the code recording medium and the code recording/reproducing apparatus of the present invention, since scramble data and scrambled main data are recorded on a sector basis, the scramble data and the scrambled main data can be read from an arbitrary sector and the scrambled main data can be restored into original data in accordance with the scramble data. Thus, any arbitrary scrambling method may be selected with respect to particular main data and an abnormal variation of the low frequency components of a reproduced signal can be effectively suppressed. As a result, the reproduced signal can be digitized with high precision and the possibility of the generation of a reproduction error can be considerably reduced. Moreover, the scramble data is changed in accordance with how many times the data has been rewritten on the same sector on an optical disk. Thus, even if the same main data is repeatedly written onto the same sector, the characteristics of the recording medium can be kept uniform on the sector, the decrease of the S/N ratio of a reproduced signal can be suppressed and the reliability of repeatedly performed recording/reproducing operations can be improved.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

What is claimed is:

1. A code conversion method comprising the steps of:

scrambling an input main data unit based on any of plural types of pseudo-random number sequences;

modulating the scrambled main data unit based on any of plural types of modulation data;

producing an output main data unit from the modulated main data unit;

obtaining a calculated value representing a difference between a number of 0 bits and a number of 1 bits included in the output main data unit; and

selecting any of the modulation data dependent upon the calculated value,

wherein the code conversion method further includes the steps of:

determining whether or not a variation of the calculated value has exceeded a predetermined threshold value;

newly selecting another pseudo-random number sequence used for the step of scrambling if it is determined that the variation of the calculated value has exceeded the predetermined threshold value; and

re-scrambling the input main data unit based on the newly selected pseudo-random number sequence.

2. A code conversion method according to claim 1, wherein the step of modulating the scrambled main data unit is performed by a first modulation having M types of modulation data,

and wherein the step of producing the output main data unit is performed by a second modulation, N types of modulation data out of the M types of modulation data causing an increase of the calculated value.

3. A code conversion method according to claim 2, wherein, in the step of modulating, the first modulation is a pit position modulation having M types of modulation data,

and wherein, in the step of producing, the second modulation is a pulse width modulation,

and wherein N types of modulation data out of the M types of modulation data causing an increase of the calculated value.

4. A code conversion method according to claim 2, wherein, in the step of determining, if the variation of the calculated value becomes equal to or larger than the threshold value K during a first period L, an output main data unit having a bit pattern which has caused the increase of the calculated value is included in a plurality of main data units to be output during the first period L,

and wherein if the pseudo-random number sequence applied to the main data unit which has caused the increase of the calculated value is called a first pseudo-random number sequence, the first pseudo-random number sequence is changed into any of a plurality of predetermined second pseudo-random number sequences,

and wherein the plurality of second pseudo-random number sequences are pseudo-random number sequences making it possible to obtain a plurality of main data units not having the bit pattern as the main data units to be produced by the step of re-scrambling and to be output during the first period L at a ratio equal to or larger than (M–N)/M.

5. A code conversion method according to claim 4, wherein if a period during which a series of output main data units are produced by the step of scrambling using the first pseudo-random number sequence is called a second period H,

the number of the plurality of second pseudo-random number sequences is at least equal to H/L=J.

6. A code conversion method according to claim 1, wherein, in the step of determining, if the variation of the calculated value has exceeded the threshold value, a part of the main data units which have been previously input before the point in time and have a predetermined length is

re-scrambled after another pseudo-random number sequence is newly selected for the part.

7. A code conversion method according to claim 1, further comprising the steps of:

obtaining a calculated value of an output main data unit corresponding to the input main data unit having a predetermined length;

newly selecting another pseudo-random number sequence and re-scrambling the input main data unit if the variation of the calculated value has exceeded the threshold value; and

obtaining a pseudo-random number sequence causing the variation of the calculated value to be equal to or smaller than the threshold value.

8. A code conversion method comprising the steps of:

scrambling an input main data unit based on any of plural types of pseudo-random number sequences;

modulating the scrambled main data unit based on any of plural types of modulation data;

producing an output main data unit from the modulated main data unit;

obtaining a calculated value representing a difference between a number of 0 bits and a number of 1 bits included in the output main data unit; and

selecting any of the modulation data dependent upon the calculated value,

wherein the code conversion method further includes the steps of:

determining whether or not an absolute value of the calculated value has exceeded a predetermined threshold value;

newly selecting another pseudo-random number sequence used for the step of scrambling if it is determined that the absolute value of the calculated value has exceeded the predetermined threshold value; and

re-scrambling the input main data unit based on the newly selected pseudo-random number sequence.

9. A code conversion method according to claim 8, wherein the step of modulating the scrambled main data unit is performed by a first modulation having M types of modulation data,

and wherein the step of producing the output main data unit is performed by a second modulation,

and wherein N types of modulation data out of the M types of modulation data causing an increase of the calculated value.

10. A code conversion method according to claim 9, wherein, in the step of modulating, the first modulation is a pit position modulation having M types of modulation data,

and wherein, in the step of producing, the second modulation is a pulse width modulation,

and wherein N types of modulation data out of the M types of modulation data causing the increase of the calculated value.

11. A code conversion method according to claim 9, wherein, in the step of determining, if the absolute value of the calculated value becomes equal to or larger than the threshold value K during a first period L, an output main data unit having a bit pattern which has caused the increase of the calculated value is included in a plurality of main data units to be output during the first period L,

and wherein if the pseudo-random number sequence applied to the main data unit which has caused the increase of the calculated value is called a first pseudo-random number sequence, the first pseudo-random number sequence is changed into any of a plurality of predetermined second pseudo-random number sequences,

and wherein the plurality of second pseudo-random number sequences are pseudo-random number sequences making it possible to obtain a plurality of main data units not having the bit pattern as the main data units to be produced by the step of re-scrambling and to be output during the first period L at a ratio equal to or larger than (M−N)/M.

12. A code conversion method according to claim 11, wherein if a period during which a series of output main data units are produced by the step of scrambling using the first pseudo-random number sequence is called a second period H,

the number of the plurality of second pseudo-random number sequences is at least equal to H/L=J.

13. A code conversion method according to claim 8, wherein, when the absolute value of the calculated value exceeds the threshold value, a part of the main data units which have been previously input before the point in time and have a predetermined length is re-scrambled after another pseudo-random number sequence is newly selected for the part.

14. A code conversion method according to claim 8, further comprising the steps of:

obtaining a calculated value of an output main data unit corresponding to the input main data unit having a predetermined length;

newly selecting another pseudo-random number sequence and re-scrambling the input main data unit if the absolute value of the calculated value has exceeded the threshold value; and

obtaining a pseudo-random number sequence causing the absolute value of the calculated value to be equal to or smaller than the threshold value.

15. A code conversion apparatus comprising:

storage means for storing an input main data unit;

scrambling means for scrambling the main data unit stored in the storage means based on any of plural types of pseudo-random number sequences;

modulation means for modulating the scrambled main data unit based on any of plural types of modulation data and producing an output main data unit from the modulated main data unit;

arithmetic means for obtaining a calculated value representing a difference between a number of 0 bits and a number of 1 bits included in the output main data unit which has been produced by the modulation means;

comparison means for determining whether or not the calculated value obtained by the arithmetic means is within a predetermined tolerance range; and

control means for instructing the scrambling means to newly select another pseudo-random number sequence and to re-scramble the main data units stored in the storage means if the comparison means determines that the calculated value is out of the tolerance range.

16. A code conversion apparatus according to claim 15, further comprising recording means for recording output data of the modulation means,

wherein the control means outputs a conversion failure signal if the comparison means has determined that the calculated value is out of the tolerance range,

and wherein the recording means re-starts recording the output data of the modulation means, in response to the conversion failure signal.

17. A code conversion apparatus comprising:

storage means for storing an input main data unit;

scrambling means for scrambling the main data unit stored in the storage means based on any of plural types of pseudo-random number sequences;

detection means for detecting a location of the main data unit which has been read out from the storage means;

modulation means for modulating the scrambled main data unit based on any of plural types of modulation data and producing an output main data unit from the modulated main data unit;

arithmetic means for obtaining a calculated value representing a difference between a number of 0 bits and a number of 1 bits included in the output main data unit;

comparison means for determining whether or not the calculated value obtained by the arithmetic means is within a predetermined tolerance range; and

control means for instructing the scrambling means to newly select another pseudo-random number sequence and then to re-scramble a part of the main data units located prior to the location of the main data unit which has been detected by the detection means at a point in time when the comparison means has determined that the calculated value is out of the tolerance range.

18. A code conversion apparatus according to claim 17, further comprising recording means for recording the output main data unit,

wherein the control means outputs a conversion failure signal if the comparison means has determined that the calculated value is out of the tolerance range,

and wherein the recording means re-starts recording the output main data unit, in response to the conversion failure signal.

19. A code conversion apparatus comprising:

storage means for storing an input main data unit;

scrambling means for scrambling the main data unit stored in the storage means based on any of plural types of pseudo-random number sequences;

detection means for detecting a location of each frame of the main data unit stored in the storage means, every time each said frame is sequentially read out from the storage means;

modulation means for modulating the scrambled main data unit based on any of plural types of modulation data and producing an output main data unit from the modulated main data unit;

arithmetic means for obtaining a calculated value representing a difference between a number of 0 bits and a number of 1 bits included in the output main data unit;

comparison means for determining whether or not the calculated value obtained by the arithmetic means is within a predetermined tolerance range; and

control means for instructing the scrambling means to newly select another pseudo-random number sequence and then to re-scramble a plurality of frames located prior to the frame, the location of which has been detected by the detection means, at a point in time when the comparison means has determined that the calculated value is out of the tolerance range.

20. A code conversion apparatus according to claim 19, further comprising recording means for recording the output data of the modulation means,

wherein the control means outputs a conversion failure signal if the comparison means has determined that the calculated value is out of the tolerance range,

and wherein the recording means re-starts recording the output data of the modulation means, in response to the conversion failure signal.

21. A code conversion apparatus comprising:

storage means for storing at least one sector of input main data units;

scrambling means for scrambling the at least one sector of main data units stored in the storage means based on any of plural types of pseudo-random number sequences;

modulation means for modulating the scrambled main data units based on any of plural types of modulation data and producing output main data units from the modulated main data units;

arithmetic means for obtaining a calculated value representing a difference between a number of 0 bits and a number of 1 bits included in each of the output main data units;

comparison means for determining whether or not the calculated value obtained by the arithmetic means is within a predetermined tolerance range; and

control means for instructing the scrambling means to newly select another pseudo-random number sequence and then to re-scramble the at least one sector of main data units stored in the storage means if the comparison means has determined that the calculated value is out of the tolerance range.

22. A code conversion apparatus according to claim 21, further comprising recording means for recording the output main data units,

wherein the control means outputs a conversion failure signal if the comparison means has determined that the calculated value is out of the tolerance range,

and wherein the recording means re-starts recording the output main data units, in response to the conversion failure signal.

23. A code recording medium for recording/reproducing main data thereon/therefrom on a sector basis,

wherein scramble data and scrambled main data are recorded in every sector,

and wherein the scramble data is represented by any of initial values of predetermined pseudo-random number sequences for scrambling the main data,

and wherein each of the pseudo-random number sequences is comprised of a plurality of random numbers beginning with an initial value of the pseudo-random number sequence,

and wherein the main data has been scrambled by sequentially performing a logical operation on the pseudo-random number sequence representing the scramble data and the main data.

24. A code recording medium according to claim 23, wherein each of the pseudo-random number sequences is a maximum length sequence.

25. A code recording medium according to claim 23, wherein the scramble data indicates whether or not a sector of main data is scrambled.

26. A code recording medium according to claim 23, wherein the scramble data is set based on the random numbers.

27. A code recording medium according to claim 23, wherein the scramble data is set in accordance with how many times main data has been rewritten on the same sector.

28. A code recording apparatus for scrambling and recording main data on a sector basis on a recording medium, comprising:

scramble data generation means for generating scramble data represented by any of a plurality of predetermined pseudo-random number sequences;

pseudo-random number sequence generation means for generating the pseudo-random number sequences in accordance with the scramble data, each of the pseudo-random number sequences being represented by the scramble data;

scrambling means for scrambling the main data by sequentially performing a logical operation on the generated pseudo-random number sequence and a sector of main data:

modulation means for modulating the scrambled main data; and

recording means for recording the modulated main data together with the scramble data onto a sector on the recording medium.

29. A code recording apparatus for scrambling and recording main data on a sector basis on a recording medium, comprising:

scramble data generation means for generating scramble data represented by any of a plurality of predetermined pseudo-random number sequences;

pseudo-random number sequence generation means for generating the pseudo-random number sequences in accordance with the scramble data, each of the pseudo-random number sequences being represented by the scramble data;

scrambling means for scrambling the main data by sequentially performing a logical operation on the generated pseudo-random number sequence and a sector of main data;

modulation means for modulating the scrambled main data;

recording means for recording the modulated main data together with the scramble data onto a sector on the recording medium;

arithmetic means for obtaining a calculated value representing a difference between a number of 0 bits and a number of 1 bits included in the modulated main data; and

a determination means for determining the calculated value.

30. A code recording apparatus according to claim **28**, wherein the pseudo-random number sequence generation means generates the pseudo-random number sequences in accordance with not only the scramble data but also sector identification data for identifying each sector of the recording medium.

31. A code recording apparatus according to claim **29**, wherein the pseudo-random number sequence generation means generates the pseudo-random number sequences in accordance with not only the scramble data but also sector identification data for identifying each sector of the recording medium.

32. A code recording apparatus according to claim **28**, wherein the scramble data generation means outputs the respective pseudo-random number sequences in a predetermined order.

33. A code recording apparatus according to claim **29**, wherein the scramble data generation means outputs the respective pseudo-random number sequences in a predetermined order.

34. A code recording apparatus according to claim **28**, wherein the scramble data generation means selects each of the pseudo-random number sequences based on the random numbers and then outputs the scramble data representing the selected pseudo-random number sequence.

35. A code recording apparatus according to claim **29**, wherein the scramble data generation means selects each of the pseudo-random number sequences based on the random numbers and then outputs the scramble data representing the selected pseudo-random number sequence.

36. A code reproducing apparatus for reproducing main data from a recording medium for recording/reproducing the main data thereon/therefrom on a sector basis, scramble data and scrambled main data being recorded in every sector, the scramble data being represented by any of initial values of predetermined pseudo-random number sequences for scrambling the main data, each of the pseudo-random number sequences including a plurality of random numbers beginning with a unique initial value, and the main data having been scrambled by sequentially performing a logical operation on the pseudo-random number sequence representing the scramble data and the main data, the code reproducing apparatus comprising:

read means for reading out the scramble data from a sector of the recording medium;

pseudo-random number sequence generation means for generating a pseudo-random number sequence for descrambling the scrambled main data in accordance with the read out scramble data; and

de-scrambling means for restoring original non-scrambled main data by sequentially performing a logical operation on the pseudo-random number sequence and the sector of main data.

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